Vol. VIII. NOVEMBER, 1891. No. 7.

AMERICAN METEOROLOGICAL JOURNAL.

A Monthly Review of Meteorology and Medical Climatology.

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ANN ARBOR, MICH., U. S. A.:

METEOROLOGICAL JOURNAL COMPANY.

19, 21 and 23 Huron Street.

AGENTS: B. Westermann & Co., New York; 2 Thalstrasse, Leipzig; and 189 Boulevard St. Germain, Paris.

Single Copies, 30 cents. Per Annum, $3.00. In European Countries, $3.25.

Entered at the Ann Arbor Postoffice as Second Class Matter.

AMERICAN METEOROLOGICAL JOURNAL.

AN ILLUSTRATED MONTHLY

DEVOTED TO SCIENTIFIC METEOROLOGY AND ALLIED BRANCHES OF STUDY.

THE AMERICAN METEOROLOGICAL JOURNAL CO., Publishers and Proprietors,
Ann Arbor, Michigan.

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PRICE,—IN THE UNITED STATES, - - - - $3.00 per year
" IN COUNTRIES OF THE POSTAL UNION, - - 3.25 " "

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THE AMERICAN
METEOROLOGICAL JOURNAL

VOL. VIII. ANN ARBOR, MICH., NOVEMBER, 1891. NO. 7

ORIGINAL ARTICLES.

FOUR BALLOON VOYAGES.

PROFESSOR H. A. HAZEN.

Readers of this JOURNAL will remember that there were published, in February of the present year, extended observations made in several balloon voyages by Mr. Hammon under the auspices of the Signal Office. These observations were made in a balloon of 25,000 cubic feet capacity and were necessarily at rather moderate heights. It has been my fortune, through circumstances beyond my control, to be engaged in three rather high balloon voyages, and I have thought it might add a little to what had already been published if I should give these records in detail. I had hoped to add many scores of voyages to these before this but that seems impracticable for the present.

A word regarding balloon observations, their accuracy, the safety of the observer, etc.

Till very recent times fixed thermometers were used in all balloon voyages, and as a result, since there was no ventilation for one in a balloon feels no current whatever, the temperature of the same stratum going up and coming back would differ by as much as 20° F. In 1884, however, the sling psychrometer came into use and this instrument, because of its extreme accuracy, perfect ventilation, portability, etc., has left nothing to be desired in this line. The availability of this instrument for balloon purposes is now being recognized abroad and several

voyages in Europe have already demonstrated its extreme value. It is probable that most every one is disposed to regard ballooning as a very dangerous occupation, and they are led to this view largely by reading accounts of fatalities that have occurred with hot air balloons and to persons that have jumped out with parachutes. It will be recognized readily that regular ballooning is entirely free from these dangers. The use of the long and heavy drag rope, of the modern anchor, of the valve at the top of the balloon and of the rip cord have rendered the balloon a very reliable means of locomotion, and especially of observation in a vertical direction in the atmosphere.

In this connection I am constrained to note briefly a rather remarkable story that was concocted in this country not long ago. The scene was laid in England in 1824. A gentleman and his betrothed, so the story goes, had taken a little excursion in a balloon. After reaching a comfortable height it was decided to descend, and for this purpose the valve was opened to allow a little gas to escape, but to the horror of the occupants of the car the valve did not work properly and remaining partly open caused the balloon forthwith to acquire a constantly accelerated motion. In despair, finally, and to save the life of the lady, the other occupant cast himself head long to the earth and was dashed to pieces. The lady swooned but reached the earth in safety. This seems quite plausible at first sight, but we become very doubtful as to its truth when we reflect that the valve is a very recent invention, that no one at the time made mention of this occurrence, that it did not get into any English literature, and that several times balloons have exploded in mid air letting out all the gas instantly and the occupants have reached the earth safely. As a matter of fact the sudden release of such a weight would be far more dangerous to the balloon than if one remained in the car; moreover, precisely the same result would have been attained if the gentleman had jumped out when he was ten feet from the earth and thus both would have been saved. Certainly I would safely say that no one need have any fear in stepping into a modern balloon car. The only difficulty he will be subjected to will be a little sea-sickness if the car strikes the earth a few times before a landing is effected.

FIRST VOYAGE.

On June 26, 1886, at the 250th anniversary of the founding of Providence, R. I., an opportunity was given for an exploration

of the air by a balloon. The day was dismal and rainy, and I may say the thoughts of at least one of the balloonists were anything but pleasant. A never to be forgotten sight was that of the thousands of umbrellas that were spread in Dexter park that afternoon. The balloon, "City of Boston," of 40,000 cubic feet capacity, had four passengers besides a large amount of ballast, and I learned that it was not the intention to make a high voyage, but rather a long one. We did not at any time rise above 1,000 feet and, finally, at dusk, after a great deal of difficulty, we found ourselves rather securely anchored in a tree-top in Voluntown, Conn. Some Rhode Islanders, hearing our shouts, came to our rescue and pulled us back into their state. The sides of the balloon had been chafed by large hickory branches, many of which were broken in the netting, and the chances for a voyage the next day seemed exceedingly slim. The basket was filled with rocks and on returning the next morning the balloon was found in perfect condition.

SECOND VOYAGE.

Professor James Allen, the æronaut, and myself took our places in the car at 7:50 A. M., and immediately began a rather rapid ascent up to 9,780 feet.

The detailed observations will be found in Table I. At about 1,000 feet we entered a dense cloud which, however, seemed more like a dry fog than air saturated with vapor. The temperature from the earth up to more than half way through the cloud varied hardly a degree, but after that it rose very rapidly, over 7° in less than 800 feet. A commotion in this cloud mass was very carefully looked for but none was seen. Above the clouds the scene was magnificent in the extreme, perfect whiteness in the clouds which appeared like beautiful billows hundreds of feet in height and extending in all directions to the limit of vision. After an hour had elapsed since entering the cloud, we heard an ominous sound which was a perfect simulation of a tug-boat on the ocean letting off steam, and though we had life preservers yet it seemed wise to leave this enchanted world and learn what was awaiting us below. On emerging from the cloud we found ourselves in Providence, about five miles from the starting point of the day before, and the tug we had heard was converted into a steam saw-mill. An examination of the observations shows a region of marked dampness at 7,000 feet elevation with relative dryness on either side.

TABLE I.

SECOND VOYAGE, JUNE 25, 1886.

No.	Time.	Dry.	Wet.	Pressure.	D. P.	R. H.	Height.	V. P.	P+P₀.	Remarks.
1	7.50	61.3	60.2	29.5	059°	94%	300	.499	...	Start.
2	.54	59.3	....	29.3	4...	....	450	....	..	
3	.58	59.4	....	29.2	7...	....	530	....	...	
4	8.2	58.7	....	29.1	4...	....	640	....	...	Passing into clouds.
5	8.8	58.4	....	28.6	0...	....	1160	....	...	In clouds, like dry fog.
6	8.10	58.4	....	28.3	9...	....	1370	....	...	
7	.12	58.3	....	28.0	9...	....	1670	....	...	Partly out of clouds.
8	.15	60.4	....	27.8	7...	....	1890	....	...	
9	.18	62.3	...	27.7	7...	....	2000	....	...	
10	.21	65.6	59.5	27.3	456	71	2450	.448	.90	
11	.25	63.0	59.5	26.7	657	82	3060	.464	.95	
12	.28	60.0	53.4	25.6	849	68	4200	.347	.69	Sun fairly bright; cirrus above.
13	.32	58.2	53.0	24.5	850	75	5410	.360	.72	
14	.37	56.0	53.0	23.7	351	82	6430	.373	.75	
15	.41	52.6	52.0	23.3	251	94	6910	.373	.75	
16	.44	53.0	51.3	22.9	850	91	7330	.360	.72	
17	.49	53.3	48.0	22.7	244	72	7670	.287	.57	
18	.54	52.5	46.4	22.4	142	69	8060	.266	.53	
19	.56	52.3	46.0	22.2	041	66	8340	.256	.51	Shadow of ball'n and anthelia.
20	.59	50.0	45.5	21.8	342	74	8820	.266	.52	
21	9.4	48.2	45.0	21.4	842	79	9250	.266	.52	
22	9.12	48.0	44.5	21.1	542	79	9660	.266	.51	
23	.16	48.0	44.2	21.1	742	79	9640	.266	.51	
24	.17	....	....	21.0	8...	....	9760	....	...	Valve opened.
25	.18	....	....	21.0	6...	....	9780	....	...	
26	.20	53.2	....	22.1	3...	....	8420	....	...	
27	.27	54.5	....	24.2	0...	....	5800	....	...	
28	.29	57.0	54.2	25.8	053	86	4040	.402	.78	
29	.31	....	....	28.5	0...	....	1260	....	...	Out of clouds.
30	.33	....	....	29.7	4...	....	....	....	...	Landed.
31	9.39	64.2	61.8	29.7	460	87	....	.517	...	Wind light N.E.
32	1147	67.2	63.3	29.7	861	81	...	.536	...	On ground.

The clouds were only about 1,000 feet thick but rain began falling just after we landed. Perhaps the most important result from this voyage was the discovery of a method by which one can determine his approximate direction of motion when above the clouds. This has been a great desideratum, since out of sight of land one is more at sea than on the ocean, for the balloon revolves and the compass is entirely useless, even the sun gives us no help. Since the balloon is sailing in a current which

is continually changing its velocity we may get the direction of this current by suspending on separate cords a heavy lead weight and a very light balloon; the moment the velocity of the current changes the small balloon and the lead weight part company and the plane passing through the two cords gives the direction within 180°, that is, if the plane lies north and south, as shown by the compass, the balloon must be moving in one of those directions. In the subsequent voyages the accuracy of this method was abundantly established.

THIRD VOYAGE. "THE WORLD" BALLOON.

It was proposed and hoped to make the longest voyage on record with this balloon of over 160,000 cubic feet capacity, and had it not been for an accident this hope would have been realized. St. Louis was selected as the point of embarkation, and the day set was June 11, 1887. It had been agreed, however, that the balloon should not go till the air currents were favorable. Many attempts had been made with large balloons to make long voyages but all had failed except one, and in these cases a little study would have shown that no long voyage could be made with air currents flowing as they were. Professor Wise and three companions made a most remarkable voyage from St. Louis to Henderson, N. Y., on July 4, 1859, covering 870 miles in about nineteen hours, or at the rate of nearly fifty miles per hour, a most extraordinary velocity and voyage.

On the day set (June 11) it was found that the currents were setting strongly to the westward. It may be said that this setting of the upper currents for nearly ten days to the westward was very remarkable and entirely unheard of in the Atlantic states. Daily bulletins were issued and explanations offered for the delay. Finally on June 16th it was announced that the start would be the next day. About 5:30 P. M., June 17, the balloon was let go with four passengers and a little over 1,000 pounds of ballast. The gas flowed so slowly through a four-inch and a six-inch pipe (which the company said was equal to a ten-inch) that the balloon was only three-fourths filled, but it did not seem wise to delay the ascension longer, especially as the high wind was making things very lively for the balloon, thrashing it back and forth about sixty feet from the basket. Just as the balloon cleared the grand stand it was probably struck by a little whirl in the air that caused it to rapidly descend toward the earth. Ballast to the extent of 400 pounds was immediately thrown over (an amount which it was expected would last till the next

morning). As a result the balloon instead of flying along at the height of 500 feet, as had been anticipated, immediately shot upward to a height of 15,400 feet. The greatest danger during the whole voyage was just during this extremely rapid upward flight, and had not the balloon been extra strong and brand new the chances are it would have burst from the very rapid expansion of the gas. As it was, the neck of the balloon, which is always left wide open for this very purpose, began to open at 11,000 feet, and at 12,000 feet the gas began to flow out so that at the highest point we had lost a good deal of the original amount. The temperature, which had been 92° in the shade at Sportman's Park, at the highest point dropped to 36°. This enormous cooling was hardly felt by the voyagers, but it served to contract the gas in the balloon and after about twelve minutes the balloon began to descend with an accelerated motion which, however, became constant in a little while. As we neared the earth over 200 pounds more ballast was thrown out and we took a grand sweep rising this time to 6,600 feet. After descending from this height, finding night rapidly coming on and a great deal of ballast gone we decided to land. This landing was accomplished with great difficulty, however, for there was a west wind of twenty-five miles per hour which treated the balloon like a great kite. The landing was finally made at Hoffman, Ills., which we found was fifty-five miles from our starting point. While the primary object of the expedition was thus defeated yet the scientific observations were vastly more valuable than they would have been had there been a long voyage. Table II exhibits these observations.

The most noticeable fact, perhaps, is the very great dryness in the upper strata traversed. At the earth the dewpoint was 63° and at 15,400 feet it was only 7°. A second point is that there were two rather sharply defined layers of dampness at about 7,500 feet and at 12,000 feet. At the latter level it was apparent to the senses that we were passing through a light mist. These observations are interesting as they have been corroborated by Vettin of Germany, who has found that there are rather definite and sharply defined cloud layers in the atmosphere and not a general vertical distribution of cloud masses. It should be noted that in the table the time set against each observation is that of reading the sling psychrometer, the time for the barometer was a few seconds later, but as the aneroid lagged a little it is believed that the error is slight.

TABLE II.

THIRD VOYAGE "WORLD" BALLOON JUNE 17, 1887, FROM ST. LOUIS, MO., TO HOFFMAN, ILLS.

No.	Time.	Dry.	Wet.	Pressure.	D. P.	R. H.	Height.	V. P.	P÷Po.	Remarks.
1	14.34	90.6	71.7	.....	63°	39%	.....	.575	...	On ground sportsman's park.
2	15.23	91.6	71.4	.....	61	36	.....	.536	...	Wind gusty SW. On ground.
3	16.14	91.8	72.0	.....	62	37	.....	.555	...	Wind brisk. On ground.
4	17.26	....	....	29.33	...	....	.....	.....	...	Started.
5	17.32	81.2	65.0	26.63	56	43	3440	.448	.81	
6	17.35	....	...	24.95	...	....	.....	....	...	
7	17.39	65.0	56.2	22.60	51	61	8120	.373	.66	
8	17.40	63.2	53.6	22.11	47	55	8730	.322	.58	
9	17.42	59.2	50.2	21.40	44	57	9640	.287	.51	
10	17.44	53.3	47.8	20.82	44	72	10360	.287	.51	
11	17.45	48.2	44.1	20.20	41	76	11170	.256	.47	
12	17.47	45.7	37.7	18.76	30	56	13240	.166	.30	
13	17.50	40.4	31.4	18.18	21	46	14040	.114	.21	
14	17.52	39.8	28.3	18.02	11	30	14290	.074	.14	
15	17.55	40.0	28.9	17.67	14	34	14850	.085	.15	
16	17.58	37.0	27.8	17.52	12	36	15040	.078	.14	
17	18.2	40.0	29.1	17.78	15	36	14670	.088	.16	Above clouds.
18	18.6	40.0	28.0	17.52	11	30	15080	.074	.13	
19	18.9	36.0	24.8	17.28	7	29	15410	.062	.11	
20	18.14	40.4	27.9	18.20	8	27	14010	.065	.12	
21	18.17	44.3	35.9	18.92	27	52	12970	.147	.27	
22	18.18	42.8	40.8	19.53	40	88	12060	.246	.44	Passing through mist.
23	18.22	51.4	47.8	20.98	45	81	10120	.298	.54	
24	18.24	58.9	51.0	22.38	46	62	8350	.310	.56	
25	18.27	64.4	57.4	23 70	53	67	6750	.402	.73	
26	18.31	72.3	61.9	26.00	56	57	4110	.448	.81	
27	18.33	81.3	66.8	27.70	59	48	2290	.499	.89	
28	18.35	85.0	68.6	28.60	60	43	1360	.517	.94	
29	18.39	89.4	70.4	28.70	61	39	1250	.536	.97	Twenty miles from St. Louis.
30	18.42	88.0	70.1	28.40	61	40	1570	.536	.98	
31	18.46	84.2	67.2	27.44	57	41	2570	.464	.85	
32	18.47	82.0	66.2	27.10	57	43	2930	.464	.85	
33	18.52	81.0	65.1	26.45	56	43	3640	.448	.81	
34	18.53	77.8	63.3	26.32	55	46	3760	.432	.79	
35	18.55	78.5	64.3	26.32	55	46	3760	.432	.79	Very near Carlyle, Ill.
36	18.57	76.1	62.8	26.02	56	50	4090	.448	.81	
37	19.2	74.7	62.3	26.25	55	49	3830	.432	.79	
38	19.5	79.3	65.3	27.04	58	48	2930	.481	.87	
39	19.8	80.1	65.4	26.80	58	47	3240	.481	.87	
40	19.13	77.4	64.0	26.20	57	50	3890	.464	.85	

TABLE II.—(CONTINUED.)

No.	Time.	Dry.	Wet.	Pressure.	D. P.	R. H.	Height.	M. P.	P ÷ P_o.	Remarks.
41	19.18	72.0	60.4	25.20	54°	53%	5000	.417	.76	
42	19.21	69.6	59.0	24.63	52	54	5650	.387	.70	
43	19.23	66.6	57.0	24.33	52	57	5980	.387	.70	
44	19.29	66.0	57.8	23.85	53	63	6540	.402	.73	
45	19.32	65.2	56.4	23.80	51	61	6600	.373	.66	
46	19.36	66.8	57.0	24.30	51	55	6010	.373	.66	
47	19.41	66.5	57.2	24.20	51	58	6120	.373	.66	
48	19.45	68.0	59.1	25.10	54	60	5090	.417	.76	
49	19.51	74.8	63.4	26.38	57	55	3670	.464	.85	
50	19.58	81.7	66.5	27.80	59	46	2160	.499	.91	
51	20.4	84.3	68.0	28.30	59	43	1660	.499	.91	Anchored to a tree Hoffman, Ill., at 20.17.

FOURTH VOYAGE.

On August 13, 1887, an opportunity was granted to make a balloon ascension in Philadelphia. The original plan was to have had the ascension on Independence Day, but the high wind interfered. The balloon, "The Great Northwest," was of 100,000 cubic feet capacity, and bore aloft seven passengers. This balloon has probably had more remarkable experiences than any ever built before. There was planned for it a voyage from Minneapolis to the seaboard with seven passengers, which had an ending in Knaphide's pasture, a few miles away. It went up a few months later from Chicago, whence it was wafted to the wooded portions of Wisconsin, and was left in the ice and snow of the whole winter.

In many respects this was the most remarkable ascension of the four and revealed a state of dessication in the atmosphere very rarely experienced before. Glancing at Table III it will be seen that at the highest point reached, 6,940 feet, the relative humidity was eight per cent., and the dew point —6°, but in ascending through the stratum at 6,410 feet, these quantities were five per cent. and —16°, and in descending through the same stratum, 6,410 feet, these quantities were four per cent. and —20°. This is all the more remarkable as the coincidence was not noticed till all the computations had been completed. There is still another remarkable and unlooked for coincidence in this table. The column headed $P \div P_o$ has been computed from Dr. Hann's plan and represents the ratio between the vapor pressure at sea level, or at starting and ending, with that

at each point in the voyage. It will be seen that from observations 41 to 47 there is almost a perfect agreement between the relative humidity in column seven and this ratio in column ten. This agreement is not to be found in Table II, and shows a particular distribution of moisture to bring about the result. The passage over the two rivers on such a hot summer's day would be expected to show some effect from such a large body of water but none can be detected. It would be very interesting to determine the exact height at which this influence terminates. So extraordinary was this dryness that I almost doubted my own eyes and asked two of my fellow voyagers to check my reading. Observations 46 and 72 look a little suspicious in not agreeing with those before and after but they do agree *inter se* and I have no doubt there was a remarkably dry stratum just at that height. During the whole voyage there was a continual tendency for the balloon to drop which was only checked by a liberal use of ballast, this will account for some of the apparent irregularities in the figures from one observation to the next. While approaching the highest point I noted the remarkable dryness of the air and urged the æronaut, Prof. S. A. King, to go up higher, but he was very cautious and refused to do so. We found on approaching *terra firma* that the current of air was blowing toward the west. Several attempts at a landing were made but none succeeded as the velocity of the balloon jerked the drag rope from the hands of all who took hold of it. To add to our difficulties darkness was coming on and we found ourselves dodging factory chimneys, church steeples, railway trains, etc. We passed within 300 feet of our starting point (Memorial Hall) and after bowling along at quite a high speed in total darkness we were brought up rather suddenly by the end of the drag rope catching in a tree. The high wind made a kite of the balloon and an energetic application of force at the valve rope did not lower the balloon very much. One of the spectators attracted by our shouts tried to climb the tree and make fast our rope, but before he could reach it the rope loosened from its hold and the next moment we found ourselves in the branches of a high maple out of which we climbed as best we could. The only injury sustained and that by only two or three of the party was a little touch of *mal de mer* when we struck the ground just after crossing the Schuylkill. Table IV gives a summary of the more important results. The observations are too few to enable even an approximate computation of the change of temperature with height.

TABLE III.

FOURTH VOYAGE "THE GREAT NORTHWEST," PHILADELPHIA, AUGUST 13, 1887.

No.	Time.	Dry.	Wet.	Pressure.	D. P.	R. H.	Height.	V. P.	P÷Po . a	Remarks.
1	15.35	75.8	63.0	29.79	55	48	100	.432	....	On ground.
2	15.57	74.8	61.4	.....	53	46	....	.402	...	
3	16.11	75.4	62.3	.....	54	47	....	.417	...	
4	16.23	74.5	61.0	.....	52	46	....	.387	...	Fair, low cirrus moving from WNW.
5	16.38	....	....	.....	....	..	....	.....	...	Started.
6	16.40	76.0	61.0	29.40	50	41	480	.360	86	
7	16.42	72.2	59.2	29.12	50	52	750	.360	86	
8	16.43	70.8	58.9	28.76	51	48	1110	.373	89	
9	16.44	69.1	57.4	28.57	49	49	1300	.347	83	
10	16.46	68.2	57.4	28.40	49	50	1470	.347	83	
11	16.48	66.0	56.3	28.12	49	55	1740	.347	83	
12	16.54	68.2	57.8	28.01	50	52	1860	.360	86	
13	17.5	69.8	56.6	27.90	47	44	1980	.322	77	Ballast thrown out.
14	17.6	65.2	55.0	27.50	48	54	2370	.334	80	
15	17.7	63.0	53.1	26.91	45	53	2990	.298	71	
16	17.8	60.0	51.4	26.63	45	58	3270	.298	71	
17	17.9	58.4	50.9	26.48	45	61	3430	.298	71	
18	17.11	57.4	50.3	26.21	44	62	3710	.287	68	Moving due east.
19	17.13	56.4	49.3	26.13	43	65	3790	.277	66	In mist.
20	17.15	56.8	49.8	26.17	44	62	3750	.287	68	Over Schuylkill river.
21	17.19	63.0	53.2	26.97	45	53	2920	.298	71	
22	17.21	64.7	54.3	27.05	47	52	2840	.322	77	
23	17.23	62.3	52.4	27.05	44	52	2830	.287	68	
24	17.24	61.2	52.0	27.05	45	56	2830	.298	71	
25	17.26	63.8	52.0	27.13	42	45	2760	.266	63	
26	17.32	65.0	52.0	26.66	41	42	3250	.256	61	
27	17.40	66.2	56.0	28.06	49	55	1800	.347	83	
28	17.43	69.4	57.0	28.08	49	49	1790	.347	83	
29	17.46	66.5	55.7	27.13	48	53	2760	.373	89	
30	17.47	62.5	53.4	26.46	47	57	3460	.322	77	
31	17.48	58.9	51.3	25.99	46	62	3950	.310	74	
32	17.50	56.3	50.2	25.56	46	69	4410	.310	74	
33	17.51	55.8	49.8	25.46	45	68	4520	.298	71	
34	17.52	56.0	49.7	25.26	44	65	4740	.287	68	
35	17.53	54.2	47.0	25.00	41	61	5020	.256	61	
36	17.54	53.3	44.3	24.95	35	50	5060	.203	48	
37	17.55	51.6	44.2	25.06	35	52	4940	.203	48	
38	17.57	52.4	47.3	25.35	43	72	4620	.277	66	
39	17.59	55.7	49.1	25.66	44	65	4300	.287	68	
40	18.1	55.8	48.7	25.71	43	63	4240	.277	66	
41	18.3	53.8	46.0	25.25	39	56	4740	.237	56	
42	18.5	53.2	44.3	25.02	35	50	4990	.203	48	Over Delaware river.
43	18.7	54.0	43.7	25.02	33	45	5000	.187	45	
44	18.8	54.0	42.0	24.88	28	37	5150	.153	36	
45	18.10	50.8	35.0	24.55	3	13	5510	.052	12	

TABLE III.—(CONTINUED.)

No.	Time.	Dry.	Wet.	Pressure.	D. P.	R. H.	Height.	V. P.	P+Po.	Remarks.
46	18.11	51.7	33.82	4.56	— 8	9	5500	.031	7	
47	18.12	52.8	36.72	4.32	9	17	5790	.068	16	
48	18.13	53.1	35.72	4.21	1	12	5910	.047	11	Passing over Camden.
49	18.14	54.3	38.02	4.01	13	19	6150	.081	19	
50	18.15	53.4	35.22	3.98	— 1	11	6170	.043	10	
51	18.16	53.7	36.82	3.75	8	15	6450	.065	15	
52	18.17	53.5	36.42	3.71	7	15	6500	.062	15	
53	18.18	55.0	36.82	3.79	3	12	6410	.052	12	
54	18.19	54.2	34.22	3.78	—16	5	6410	.020	5	
55	18.20	55.0	35.32	3.72	— 6	8	6490	.034	8	
56	18.22	54.2	35.22	3.63	— 4	9	6590	.037	9	
57	18.22½	54.7	35.32	3.56	— 6	8	6680	.034	8	
58	18.23	54.4	35.42	3.58	— 3	10	6650	.039	9	
59	18.24	55.4	37.82	3.61	10	16	6620	.071	17	
60	18.25	54.6	35.12	3.56	— 6	8	6680	.034	8	
61	18.27	54.3	35.32	3.42	— 2	10	6840	.041	10	
62	18.28	53.3	34.32	3.33	— 6	8	6940	.034	8	
63	18.29	52.0	34.72	3.33	4	15	6940	.054	13	
64	18.30	52.0	33.32	3.43	— 8	8	6820	.031	7	
65	18.31	53.2	35.32	3.66	1	12	6540	.047	11	
66	18.32	52.8	33.62	3.62	—13	6	6590	.024	6	
67	18.35	51.8	33.92	3.62	— 5	9	6580	.035	8	
68	18.36	51.0	32.22	3.76	—20	4	6410	.017	4	
69	18.38	51.6	34.12	4.04	— 2	11	6090	.041	10	
70	18.39	52.0	33.92	4.22	— 7	9	5880	.032	8	
71	18.40	52.3	34.02	4.48	— 8	8	5590	.031	7	
72	18.41	51.4	33.22	4.64	—16	7	5400	.021	5	
73	18.42	51.0	39.42	4.78	25	36	5240	.135	32	
74	18.44	50.7	43.02	5.24	35	54	4730	.203	48	
75	18.45	52.6	44.02	5.52	35	53	4430	.203	48	
76	18.46	54.0	49.42	6.04	45	73	3870	.298	71	
77	18.47	55.0	50.02	6.26	45	69	3630	.298	71	
78	18.48	56.0	50.72	6.54	47	71	3340	.322	77	
79	18.49	58.0	52.02	7.01	47	67	2860	.322	77	
80	18.50	59.3	52.42	7.26	46	62	2600	.310	74	
81	18.51	60.4	53.02	7.53	47	63	2320	.322	77	
82	18.52	61.4	53.82	7.77	47	60	2080	.322	77	
83	18.53	63.8	54.42	8.33	47	53	1520	.322	77	
84	18.54	65.7	56.42	8.84	49	55	1020	.347	83	
85	18.55	67.9	59.02	9.40	53	58	480	.402	96	Over Chew's Landing.
86	18.56	67.7	59.42	9.52	54	61	360	.417	100	
87	18.58	68.0	59.32	9.48	54	59	400	.417	100	Going due west.
88	19.0	68.6	59.82	9.48	54	59	400	.417	100	
89	19.6	68.1	58.32	9.31	52	55	560	.387	92	
90	19.9	69.2	60.32	9.58	54	59	310	.417	100	
91	19.11	68.0	58.02	9.08	51	54	790	.373	89	
92	19.14	67.2	57.92	9.17	52	57	700	.387	92	
93	19.23	67.0	58.42	9.30	53	60	570	.402	96	Too dark to see more.
94	20.36	....	.....	....	....	..	....	....	...	Landed two miles west of starting point.

TABLE IV.

SUMMARY.

Height	Temperature.			Dew Point.			R. H.			P.			$P \div P_0$.		
	2 v.	3 v.	4 v.	2 v.	3 v.	4 v	2 v.	3 v.	4v.	2v.	3v.	4v.	2 v.	3 v.	4v.
1000	58.5	....	71	58	....	51	....	....	48	....	....	.37	....	....	89
1500	58.3	....	68	57	....	49	....	....	50	....	....	.35	....	....	83
2000	62.3	....	69	57	...	47	....	....	44	....	....	.32	....	....	77
2500	65.6	....	65	56	....	46	71	....	50	.45	....	.31	90	....	74
3000	63.0	82	63	57	56	45	82	....	53	.46	....	.30	95	....	71
3500	61.5	81	59	53	56	45	....	43	61	....	.45	.30	....	81	71
4000	60.0	74	58	50	....	45	69	....	62	.36	....	.31	69	....	74
4500	59.3	72	56	....	....	45	....	....	68	....	....	.30	....	....	72
5000	58.7	70	54	....	....	29	....	....	38	....	....	.16	....	....	37
5500	58.0	69	50	50	....	—8	75	....	8	.36	....	.03	70	....	7
6000	56.5	67	54	....	....	—1	....	...	10	....	....	.04	....	....	10
6500	55.0	66	54	51	....	—8	82	....	7	.37	....	.03	75	....	7
7000	53.0	66	53	51	....	0	94	....	9	.37	....	.04	75	....	10
7500	53.0	65	....	46	....	....	....	....	....	.30	....	....	61	....	..
8000	52.5	65	....	42	51	..	69	61	....	.27	.37	....	53	66	..
8500	52.0	63	....	42	47	....	67	55	....	.27	.31	....	52	57	..
9000	40.0	61	....	42	....	....	79	....	....	....	....	....	....	....	..
9500	48.0	59	....	42	44	....	79	57	....	.27	.29	....	51	51	..
10000	.....	56	....	....	....	....	....	....	....	....	.30	....	....	....	..
10500	.....	53	....	....	44	....	....	72	....	....	.29	....	....	51	..
11000	.....	49	....	....	41	...	....	76	....	....	.26	....	....	47	..
11500	.. ...	47	....	....	....	....	....	....	....	....	.25	....	....	45	..
12000	.....	47	....	....	40	....	....	88	....	....	.25	....	....	44	..
12500	.....	46	....	....	....	....	....	....	....	....	....	....	....	....	..
13000	....	45	....	....	27	....	....	52	....	....	.15	....	....	27	..
13500	.....	44	....	....	....	....	....	....	....	....	....	....	....	....	..
14000	.....	40	....	....	14	....	....	36	....	....	.08	....	....	16	..
14500	.....	40	....	....	....	....	....	....	....	....	.08	....	....	14	..
15000	.....	40	....	....	11	....	....	33	....	....	.08	....	....	14	..
15500	.....	36	....	....	7	....	....	29	....	....	.06	....	....	11	..

It may be thought that all this represents an enormous expenditure for exceedingly few results, but I do not think that view correct. These voyages were made distinctively for other purposes, and the meteorologic observations were a mere incident. I have no hesitation in declaring that great results may be had with slight expenditure. It is proposed to employ a balloon of 100,000 feet capacity, inflate it only half and then rise with a good velocity till 25,000 or 30,000 feet be reached. At that height the balloon would lose some of its buoyancy by the cooling of the gas and would quickly descend without losing gas. On reaching the earth it would be a simple matter to anchor and wait for the sun to heat up the gas. This operation may be repeated again and again at little or no expense. It seems to me these few results are very extraordinary and should spur us on with renewed zeal to explore the atmosphere. The

second voyage was made while the pressure conditions were nearly flat, but the third and fourth were very near high areas, the latter almost in the center of one. We want to explore the air where rain is falling, to get the temperature, thickness of cloud, etc. We want to explore in the centres and on all sides of storms and high areas. In fact, we ought to make a thorough study of atmospheric conditions, about which we know almost nothing at present.

August 31, 1891.

METEOROLOGY AT THE FRENCH ASSOCIATION.

By A. Lawrence Rotch.

At the recent meeting of the French Association for the Advancement of Science at Marseilles, the section of Meteorology and Terrestrial Physics was presided over by M. Crova, the president, M. Angot, being absent. The attendance was small and the communications were generally unimportant.

Among the most interesting was one by the well-known physicist, M. A. Crova, upon the analysis of diffused light. The instrument which he employed for this purpose resembles his photo-spectroscope. In it the light from a Carcel lamp is decomposed by a prism, as well as that received from the sky through a vertical slit, which can be more or less closed. The line 576 in the solar spectrum is taken as unity, and the spectrum from the Carcel lamp is compared with the solar spectrum. The former, therefore, serves to establish the relation of the blue rays of the sky at any time to those in the solar spectrum. Observations made at Montpelier at the zenith show the blue to be greatest in the early morning, least about 2 P. M., and then increasing until the late afternoon. The greatest values occur in winter and the least in summer, with intermediate values in the spring and autumn. A cloudy sky does not give white light, as might be supposed, but it shows a considerable amount of blue rays.

M. Ragona, director of the Modena Observatory, stated the results of his discussion of three months of bi-hourly hygrometric observations. These showed four phases, a chief maximum and a secondary maximum, a chief minimum and a secondary minimum, the times of the four phases corresponding inversely to those which M. Ragona had found for the diurnal period of temperature. For the humidity the greatest variabilty is in summer, and the least in winter; for the hours of the chief

diurnal maximum of humidity the greatest variability is in winter and the least in summer, while for the hour of the chief minimum of daily humidity, the greatest variability is in summer and the least in winter.

M. Ragona also spoke of the observations made at mountain stations, which he believed were always inexact in consequence of the disturbing influence exercised by the enormous solid mass interposed between the sea-level and the stratum of air under consideration at the observatory. He described the chief disturbing influences, and recommended the use of captive balloons instead of mountain stations.

M. Teisserenc de Bort explai ned the existence of a vertical barometric gradient, first noticed in observations at the base and summit of mountains, but lately measured more exactly on the Eiffel Tower. This gradient may depend on three causes: the dragging of the air by currents, the centrifugal force, and the inequalities in the velocity of currents, these effects being much greater near the soil than higher up. M. Teisserenc de Bort also stated his dynamic theory of cyclones as opposed to their thermal origin.

M. Doumet-Adanson proposed a change of the meteorological year, so as to accord with the solar *regime*, beginning perhaps with March, and divided into three periods. He proposed that the question should be recommended for consideration to the next International Meteorological Conference, and this wish was confirmed by the Section.

Mr. Rotch explained the system of measuring cloud heights and velocities at the Blue Hill Observatory, and gave some of the preliminary results which have been published in the July JOURNAL.

M. Léotard stated that the temperature of Marseilles during the past few years had been lower than the normal. M. Tiesserenc de Bort asked if this might not be connected with a change in the amount of cloud. Dr. Chiais, in speaking of the climate of Mentone, alluded to the temperature below freezing frequently observed, a fact often concealed by physicians.

Mr. Symons, of London, sent a paper on the rainfall along the coast of the Maritime Alps, from which it appeared that the usual amount of rain for the wettest day of the year amounts to 2.56 inches, but in certain exceptional cases the quantity may be doubled in twenty-four hours; while the quantity of rain which falls in a very dry year may amount to but half the

normal, which is a little under 31.5 inches, but, on the contrary, in a wet year this quantity may become about double the normal, so that the rainfall in a very wet year equals four times that in a very dry year.

Finally, M. J. Richards described a new instrument for registering the force of the winds, in which the errors caused by the momentum and friction of the pressure-plate, etc., were avoided. The new anemometer consists of a sphere mounted on a vertical axis, terminated by a disk with a circular knife-edge on its upper surface, which bears on a flange. Below the disk is a piston acting on a membrane covering a reservoir containing petroleum. By means of a small tube also filled with petroleum, the variations of pressure exerted by the wind on the sphere (which has but little lateral motion) are transmitted to a Bourdon tube, and thus by a system of levers are recorded on a cylinder as in the other instruments of Richard frères.

THE ZODIACAL LIGHT AS RELATED TO THE TERRESTRIAL TEMPERATURE VARIATIONS.

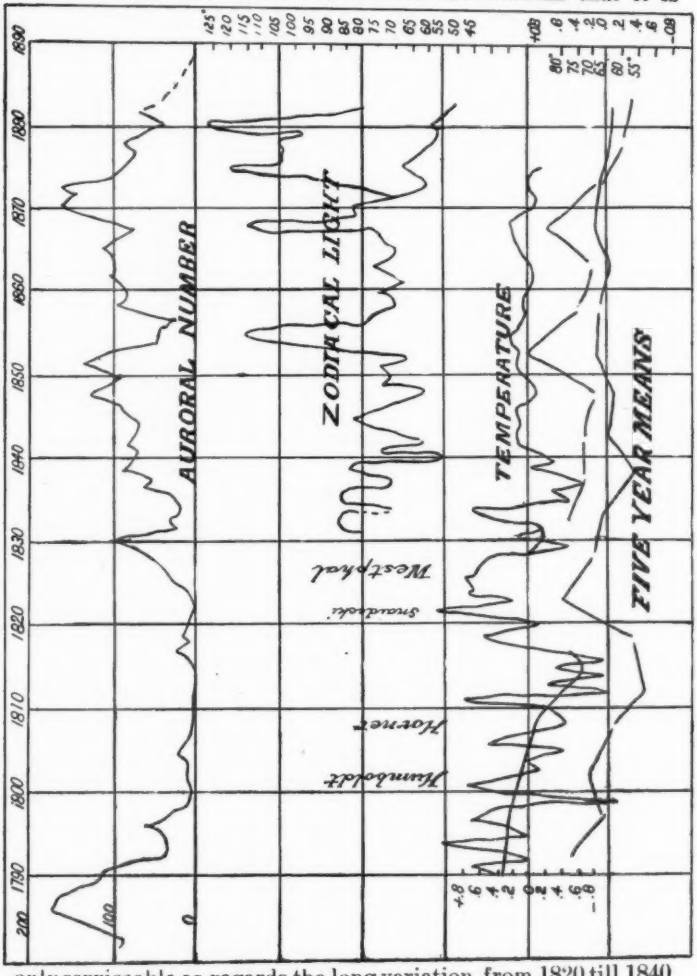
By O. T. Sherman.

It has frequently been said that the temperature variation is an exceedingly complex phenomenon. This is doubtless true, and especially true when considering the temperature of an especial district. I think, however, I have discovered that when we consider the temperature of the whole earth, the principal cause of variation is the difference in the sum of the local densities of the zodiacal light forming matter which lies between us and the sun. The evidence is as follows:

Brückner, in his Klimaschwankung, has found that the temperature of the whole earth passes through a periodic cycle once in seventy-five years (75). For one of these cycles we have some knowledge of the zodiacal light. The variation seems to be concurrent. For the earlier cycle the data are not suitable for comparison.

The following table contains in its first column the observed elongations of the zodiacal light from the commencement of the century. In 1873 there appeared on the formerly uniform light shimmer an inner cone of greater brilliancy. The elongation of this cone, while varying concurrently with the outer cone, yet constantly becomes less. The second column contains Koppen's mean yearly temperature. The values till 1840 are

taken from Fritz' well known memoir of 1878. After 1840 from the Zeitschrift of the Austrian Meteorological society, 1880. The series till 1820 is derived from so few stations that it is



only serviceable as regards the long variation, from 1820 till 1840, the approximation is better, and still better from 1840 to the end of the series. The third column gives the five yearly means

as given by Brückner. They include Koppen's values and are of especial service in corroborating the general decrease of the temperature from 1790 to 1815. The fourth column contains the corresponding five yearly means for the zodiacal light. The fifth column gives the yearly auroral numbers for Europe, south of the polar circle (Fritz). They give an indication that the zodiacal light phase in the early part of the century (1740–1820) was similar to that in the latter part (1873). These values are still further shown in the adjoining curves:

Year.	Elongation of Z. L.	Temperature Variation.		5 Year Mean of Z. L.	Auroral Number.
		Koppen.	Brückner.		
1790		+0°31			115
1791		+0.61			109
1792		−0.06			36
1793		+0.40	+0°46		35
1794		+1.00			36
1795		0.00			39
1796		+0.23			63
1797		+0.70			35
1798		+0.48	+0°07		29
1799		−1.14			6
1800		+0.17			6
1801		+0.70			17
1802		+0.33			1
1803	Humboldt	−0.18	+0.26		18
1804		−0.01			2
1805		−0.59			22
1806	Homer	+0.47			8
1807		+0.15			6
1808		−0.47	−0.18		2
1809		−0.42			1
1810		−0.30			1
1811		+0.75			0
1812		−1.06			0
1813		−0.25	−0.46		2
1814		−0.93			6
1815		−0.36			2
1816		−0.94			4
1817		−0.30			26
1818		+0.27	−0.35		8
1819		+0.50			15
1820	Snadiaki	−0°18			8
1821		+0.38			5
1822		+1.05			3
1823		+0.10	+0.56		1
1824		+0.64			8
1825		+0.60			26
1826	Westphal	+0.67			29
1827		+0.51			37
1828		+0.47	+0.14		47
1829		−0.55			62
1830		+0.11			103
1831		−0.27			64

Year.	Elongation of Z. L.	Temperature. Variation.		5 Year Mean of Z. L.	Auroral Number.
		Koppen.	Brückner.		
1832	Olbers	−0.21			20
1833	Olmstead	+0.31	+0.03	78.1?	27
1834	69.0	+0.56			14
1835	87.1	−0.55			15
1836		−0.31			23
1837	69.0	−0.71			56
1838	79.7	−0.53	−0.39	71°7	50
1839	83.1	−0.09			85
1840	54.9	−0.38			76
1841	73.6	−0.10			63
1842	60.0	+0.08			79
1843	66.3	+0.07	0.00	71.8	68
1844	77.0	+0.01			66
1845	82.3	+0.05			76
1846	71.7	+0.08			80
1847	64.5	−0.05			87
1848	60.4	−0.14	−0.05	68.2	129
1849	73.9	−0.15			100
1850	70.7	−0.08			89
1851	74.2	+0.04			101
1852	65.4	+0.05			138
1853	82.9	+0.02	+0.11	89.2	116
1854	108.9	+0.13			59
1855	114.8	+0.17			40
1856	79.9	+0.08			43
1857	75.0	−0.02			20
1858	68.9	−0.01	+0.06	73.4	66
1859	68.7	+0.02			91
1860	74.4	−0.03			78
1861	66.2	−0.12			83
1862	69.9	−0.13			99
1863	75.4	−0.08	−0.06	69.7	96
1864	70.7	−0.05			93
1865	68.6	+0.05			109
1866	72.0	+0.10			105
1867	72.0	+0.11			90
1868	112.8	+0.18	+0.11	83.1	70
1869	80.4	+0.16			113
1870	81.7	−0.04			143
1871	69.4	−0.14			159
1872	75.8	−0.11			140
1873	86.5	59.2	−0.01	+0.04	67.0	158
1874	101.5	63.6	−0.06			101
1875	119.0	66.9	−0.22			87
1876	103.3	64.8				72
1877	103.1	58.9				69
1878	104.9	57.4		−0.07	5.91	85
1879	97.3	55.8				67
1880	125.6	58.7				29
1881	92.4	53.6				53
1882	78.3	49.5		−0.08	56.3?	64
1883						38*
1884						24*

The relations which exist between the zodiacal light and the auroral curve which we have already discussed, shows us that the zodiacal light in 1790 must have been similar to that of 1870. At this phase a portion of the particles began to retreat towards the sun. For a single particle the disturbance produced in the terrestrial temperature may be considered as varying as the product of the inverse squares of the distances between the particle and sun and particle and the earth, from which we may see that the least heating effect of the particle is when equally distant from the two bodies. The increase of the density acts to disturb the similarity of this result, but yet permits us to say, that as the particles retreat towards the sun there exists a point where their heating effect will be a minimum. This point our particle had apparently reached in 1815. At this time we have no trace of the zodiacal light in the auroral number. None by observation are in the disturbance of the earth's motion. There is for this date no observation of the Corona. The solar surroundings would seem to be fairly close to the sun. A continuation of the same motion would tend to produce an increase in the temperature and such seems to be the record. The temperature increases till 1826, when we again begin to feel the effect of the zodiacal light in the aurora and also have observations. As the zodiacal light increases the temperature decreases, reaching a second minimum with what from the auroral curve should be a minimum of the zodiacal light. And from that point to the end of our series, maximum corresponds with maximum and minimum with minimum. The secondary variations appear to follow the same law, but are too slight to be of much critical value. It would seem therefore that the variation in the terrestrial temperature, when considered for the whole earth, is caused by the variation in the position density of the particles forming the zodiacal light.

In a few years we shall be able from investigations now in progress to state more fully the laws which govern the motions and positions of these particles, but we are hardly likely to do more than amplify the facts here presented.

FEATURES OF HAWAIIAN CLIMATE.

By Curtis J. Lyons,
In charge of Hawaiian Weather Service.

The main features of Hawaiian climate are, the trade-wind, and the phenomena caused by the mountains. The local climates are many, more than you will often find in like contiguity. They may be classified as:

1. The weather side trade-wind exposure.
2. The lee side trade-wind exposure.
3. The strong-trade regions.
4. The lee side land and sea breeze.
5. The weatherside land and sea breeze.

The best examples of No. 1 are Koolau on Oahu, Wailuku on Maui, Hamakua and North Hilo on Hawaii. The characteristics of these districts are, abundance of fresh atmosphere just off from the sea, with a full amount of moisture, cloudy afternoons, rainfall slightly in excess. The afternoons are shaded with the heavy masses of cumulus clouds which are blown in from seaward and rest against the mountain or forest, with showers at evening formed from the moist air striking cool peaks. Wailuku is peculiarly characterized by this, the "*malu hekuawas*," Hana on Maui, also. Of course in these districts you have fresh, bright vegetation and poor harbors.

2. The lee-side trade-wind tracts have Honolulu itself as their type. The mountains are not high enough to stop the trades, but the moisture is largely extracted by precipitation on its way over the summits, and through the deep valleys, but gains a clear, electric quality, offsetting in a measure the bright clear heat of the afternoons. Sunlight is in excess, and is one of the first things an observing stranger notices. It bathes everything—(it ought to banish the white-washed fence).

But we have a taste of mountain air. Occasionally we have the land and sea breeze, as much of our so-called "south wind" is only sea breeze. The land breeze is an imperceptible current from the Ewa or Waipio mountains at daylight. Were it not for the winter storms the rain-fall of these districts would be deficient.

3. The strong trade-wind exposures are the North and South capes of the Islands; Northwest Kohala in Hawaii, Kaupo on Maui and the south side of Molokai are of this type. The

wind blows endlessly, drearily, and uninterruptedly. The isthmus of Maui is of this type, save that the mountains at night kill the trade-wind with land breeze.

4. The weather-side land and sea-breeze type of location is Hilo Bay and neighborhood. The trades approaching the Island of Hawaii at the east point divide, one current flowing down as an east wind along the Hamakua coast, and the other as a north wind, or nearly so, down the Puna coast. A small residuum goes in over Hilo as a gentle sea-breeze by day, but at night gives way to a strong, well marked land breeze coming cold off the mountains of Mauna Loa and Mauna Kea, lowering the temperature from 10° to 15° at times. Any strong wind from any direction is rare at Hilo, the southwest gales of winter being hardly felt, and a north wind being the storm wind. It is no doubt the incessant meeting together of the warm vapor from seaward, with cool masses of air from the mountain that produces the world-renowned precipitation of Hilo of from 100 to 200 inches per year. An engineer told me he had known a sixteen-inch deep sugar cooler to be filled in the open, in one night. Fifty-five inches in a month has been reported from there, and fifty-nine from the Volcano House. Nicaragua can tell of sixty-four for one month. (Thirty-six inches in thirty-six hours, reported by Meyers of Molokai, is the most remarkable rainfall I know of). Hamakua also has a great deal of cold land breeze at night, off the north slope of Mauna Kea.

5. In contrast with this is the lee-side land and sea breeze district, extending from Mahukona to Kau on Hawaii, also Honuaula, Kula and Lahaina on Maui. Regularly here comes in the sea breeze about nine A. M., extending far inland, and as regularly comes down the land breeze soon after night fall. There is, however, another wind factor in the back current from the strong trades that sweep around the north and south points of Hawaii. The stronger the trade wind in the Hawaii Channel the stronger the sea-breeze at Kawaihae and also at Makena, Maui, showing that it is a back current, sometimes even coming in at night-time. From Kawaihae to North Kona prevail also the "Mumukus"—that is, a down rush of trade wind from Waimea, sweeping away all land and sea breezes in the wild rush of dust and fury.

This fact about down-pouring volumes of air deserves a passing explanation. It is sometimes explained on the principle of a waterfall rushing down by gravity. I think it more probably

due to compression, the sloping windward side of the mountain acting from below, and the upper stratum of air from above, compressing the air in a wedge-shaped funnel at the summit, from which the air pours out under pressure. Thus it is that the Kona or southwest wind is so much more violent in Koolau or northeast coast of Oahu, and in Kohala of Hawaii, than it is here or at Kawaihae. This does not occur when the weather side is so steep as to throw the wind upward, as it does on the northeast side of Oahu.

The sea-coast belt of this part of the group, Kona, etc., is extremely arid, but up in the forest belt rain is frequent, more so than we have generally supposed. So says the rain record of Kailua and Kealakekua.

The rain periods of our group are under the following heads, or main types:

Common trade-wind showers to be expected at any time.

The winter storms from the southwest.

The spring rains of March and April.

The July rains.

The trade-wind showers are nearly allied to the squalls encountered at sea in the strong trade-wind belts. There is generally a slight shift of wind connected with the shower, generally to the east as the shower goes off, indicating as the cause of the rain the meeting together of cool and warm bodies of air of different moisture.

Trade-wind rains are often preceded from twenty-four to forty-eight hours by a heavy northwest swell which is the cause generally of heavy surf along the reef. This surf is almost a sure forerunner of misty showers within a day or two.

Sailors say these rain squalls come at the rising of the moon, which fact we will not prove or disprove at present, though more perhaps of this further on.

The winter storms are very much varied in their action. In a normal season, if we may use the phrase, the trades begin to be interrupted in September, if we except perhaps the common sea breeze on the Fourth of July, and are much lighter than in the rougher months of July and August. Every few days the trades fail and sea breezes, light premonitions of southwest winds, come in.

The change in weather here I am pretty well satisfied comes down from the upper regions. While the regular wind is still blowing, the lower clouds, not the upper cirrus clouds, come to

a stand-still. The cumulus clouds, I should remark here, are the trade-wind clouds. Twenty-eight hundred feet may be said to be the height of their lower limit in ordinary weather, and eight thousand the upper limit. Far above these, say from ten to twenty-five thousand feet, are the cirrus clouds.

The ceaseless direction of the upper current is from the southwest, varying perhaps from SSW. to WNW. at times. It is a very rare sight indeed to see a cirrus cloud moving from the east. The column of smoke from a Mouna Loa eruption rises perpendicularly perhaps 10,000 feet, and then rolls off horizontally to the northeast. On the summit of Mauna Kea the trades are probably not usually felt excepting in midsummer, when the stratum of this wind is the thickest.

As was said, the cumulus clouds become stationary; the next day the calm reaches the ground, and the other current prevails. Changing back again, the trades begin on the surface first and work upwards.

Whether the southwest storms of the winter months are revolving, *i. e.*, cyclonic storms, or whether they are general winds, is as yet an open question; probably they are both at different times. Captain Morse, of the Alameda, and Col. Tupman thought them general winds. In some winter seasons the winds go around in the orthodox way, in other winter seasons they whip right over, holding to the north quadrant.

October is generally on the whole a pleasant month. November is the normal month for the setting in of southwest storms. The first heavy snows on Mauna Kea and Mauna Loa come with the first ten days of November. The summit of Mauna Kea is almost exactly on the perpetual snow line, as averaged, the entire disappearance of all snow-banks being the exception, not the rule. Snow falls as low as 7,000 feet at rare intervals.

The heaviest rainfall of the year is in November and February. December and January are variable months, *i. e.*, year by year, sometimes the finest kind of weather all through; sometimes storms long continued and violent prevail; sometimes only northerly rains prevail. A trade-wind winter, the beau-ideal of some, is not a healthy season because abnormal, and sickness and mortality, especially among native Hawaiians, is greater than when the regular southerly weather is in due proportion, much as has been said against the hated so called south wind. Nothing affects the native worse than the north or north-

westerly wind. I do not know that this country is alone in this regard.

February is generally rainy, whichever kind of winds prevail.

March and April are marked by the rains that set in with the returning trades, very *wet* rains, one may say. On the northeast coast of Hawaii these are very marked and heavy. I have noticed a heavy continuous cloud over Hilo and another over the Kohala Mountain for weeks at a time, the drenching showers flying across from one to the other over the district of Hamakua. These rains are more marked on Hawaii than on Oahu.

With May the Hawaiians say "*puka iwaho*," come out into fine weather again. A noted sign of weather with them is as follows: While clouds hang over the sea, and it is clear on the high mountains, then expect rain; when clear space is over the sea, and clouds over the land on the mountains, then fine weather. "*Halii ka luahine*," the old woman of the sky spreads her mat (overhead).

June is still more fine, but with the vertical sun comes a more-felt midday heat than of any other month, and less wind, but cool nights. July and August are called "*malama ino*" by the natives, and for canoe voyaging and channel trips are pretty rough. July rains are trade-wind rains born of the accumulating heat.

The southeast trades of the South Pacific are most prevalent, as I have said, at the same time that they are in the North Pacific, a circumstance that seems curious. And the rainy season in the South Pacific is November and December, when we should expect matters to be reversed. In Malaysia July and September are also rainy. The belt dividing the two trades appears to be always north of the equator. March is the hurricane season around Fiji and Samoa, when the Northwest Monsoon is reaching down from near New Guinea.

The much-remarked feature of our climate is the coolness of it, considering the latitude. It is ascribed sometimes to distance from continents, but South-Sea Island temperatures are higher. Tahiti is full 5° F. warmer than Hawaii. The Bahama Islands also, further north than we are, are warmer. The West Indies I have already characterized.

The charts which give the currents and surface temperature of the sea shed light on this question. The Kuro Sivo current, as we know sweeps up the coast of Japan (as the Gulf Stream of the Pacific) then partly into the Behring Sea, and partly

down the coast of Alaska and Oregon. In harmony with this a current comes from Oregon and California in a southerly curving direction to these Islands, bringing of course a cool temperature with it as well as the drift logs of Columbia River, to attest its existence, and dropping them on our SE coasts. I once noticed a dozen or more strung along the beach along Ka Lae in South Kau, Hawaii. An immense one in Kaupo Maui, and along Koolau of this island they come ashore. The surface temperature of this current here is probably 74° or thereabouts, just our average heat.

Around Tahiti the ocean temperature comes at 80°. Around the Bahamas the same. Saint Helena, in the South Atlantic, is the counterpart of Hawaii, cooled even more by the ocean flow from Cape of Good Hope to a temperature of 71°. So we have America to thank for our climate on the one side and New Guinea on the other. (Rio Janeiro is like us in heat also.)

Our averages for January are 69° to 71° in different years. In July and August 78° and 79°. The daily range is greater than is generally supposed, averaging in 1890, 11° F. for the year, and some days over 20°. This is the first record I have known of here of maximum and minimum. In ten years I have never seen the temperature at 90°, a few times at 89°, and there are a dozen or twenty entries of 88°.

The minimum is not generally at sunrise, but probably about 3 A. M., and the maximum at 1 P. M., or before. There is a great difference in the minimum of different winters, some not going below 60°, some dropping to 55° every now and then. I would repeat here that the SW. wind is a cool one, and the NE. warm; the first feature of a returned trade being a higher thermometer in the evening.

One principal barometric phenomenon is as follows: Whereas in temperate climates the weather range is great, the diurnal wave there is small, and buried up almost unnoticed and unknown to common observers. Here the latter is as regular as the return of day itself, being the highest on an average at 9:30 A. M., and lowest on an average at 3:30 P. M., rising and falling generally .07 of an inch. What causes it? I have never seen a satisfactory explanation in such meteorological literature as I have had access to. The numerous causes assigned for the phenomenon being, first, too local and limited in extent; second, too liable to variation, while the phenomenon itself is regular

and extensive. For a year or two past I have held to the following explanation, and beg to offer it in this connection, namely: As the earth rolls eastward, meeting the morning sun, there travels westward a belt or strip extending north and south, in which the atmosphere is rapidly warming up with the sun's heat. This atmosphere must expand, and not only expand upward but laterally.

It is the *lateral pressure of this expanding front rank of day-heated air* that raises the barometer ahead of it. A heat maximum arrived here, rarefies the air, but 1,000 miles east of us it presses by expansion upon the air here, nor does any wind or current of air necessarily accompany this pressure.

Shut all the doors and windows in a room, but leaving one door just ajar; now open a door suddenly on the opposite side of the room and this one will shut; *vice versa*, quickly shut a door on the opposite side and this one will open. When the cooled air of evening is arrived at a point, say 1,000 miles east of us, a partial vacuum in front of it takes place through its concentration, and the barometer here falls. When the cold arrives here the mercury rises again.

Now then a wave-motion, or rising and falling, is established, which repeats itself in the night to receive a new impetus on the return of the day. There is not room in this article to give the various bearings of this subject.

The character of the annual movement of the barometer does not appear till you have a series of years of observations. We have twelve years, and the means show a minimum in February, a maximum in May, with a slow but perfectly regular descent to the next February. I believe that this too is caused by the approaching solar heat from the south, as the season comes north. As the sun goes back the same way it came we have but one maximum.

The Isobaric chart of the Pacific Ocean shows some curious facts of air pressure. It is highest in two areas, one northeast of Hawaii, whence come our trades, and one southeast of Tahiti, whence come theirs. Corresponding to these is the comparative vacuum or low pressure in the East Indies, into which the winds blow. Thus the trades follow the law of surface winds, namely: out of high areas into low areas.

METEOROLOGICAL WORK OF AGRICULTURAL EXPERIMENT STATIONS AND AGRICULTURAL COLLEGES, AND THEIR RELATIONS TO THE WEATHER BUREAU.*

By Mark W. Harrington.

The relations which should exist between agricultural experimental stations and agricultural colleges and the Weather Bureau are not easy to define. It is not difficult, however, to state what kind of meteorological work experimental stations and agricultural colleges should perform. For two reasons, they should not be telegraphic meteorological stations: first, they are not in a position for receiving and sending telegraphic observations generally. The stations where observations are received and sent telegraphically must be selected with reference to ease of telegraphic communication. The requirements of their selection will not admit of experimental stations or agricultural colleges. Secondly, some of the work required of telegraphic stations, which must be done rapidly and at certain fixed and often unusual hours, cannot well be done at experimental stations or agricultural colleges.

Again, in general, agricultural experimental stations and agricultural colleges should be located in the open country, and therefore cannot be made central stations for state weather services. The latter should be located, when possible, at commercial centers.

Nevertheless, there is a large field of meteorological work which agricultural colleges and experimental stations can very properly occupy and which should be assigned them. They should generally be made meteorological stations of the first order, on the international plan, and their special duty should be climatological research. A station of the first order is, in general terms, one where hourly observations are taken and recorded by self-registering instruments. These observations are especially suitable for climatological work; they should be taken in some quiet place; the observer should have ample leisure to watch his instruments and assure himself of their accuracy; and afterwards the observations should be carefully reduced by the observer. All this requires much time and care on his part. The conditions at experimental stations and agricultural colleges are peculiarly adapted to this kind of work,

*Read at the Conference of Agricultural Colleges and Experiment Stations in Washington in August.

and, moreover, this work is of especial interest to agriculture. The observations referred to should be published in full, and on the international plan.

To this general climatological work these stations should add some special meteorological investigations; such, for instance, as the relation of forests to climate, reactions of the soil and climate the influence of climate; upon vegetation and the inverse influence of vegetation upon climate; the relation of the stages of plant growth to the season, and similar topics. Such work is already performed by similar stations in the Old World, especially in Germany. As an example of what such stations should do in this class of work, I would suggest the investigations carried on at the station at Munich, in charge of Professor Wollny.

It is difficult to say exactly what the relations of the Weather Bureau to these stations should be. The Bureau should undoubtedly furnish the instruments used at the stations, or at least should ascertain their corrections and certify to their accuracy. The Weather Bureau should also have the instruments and the work inspected from time to time, to insure uniformity, and the work at the different stations should be planned after that of the Bureau itself. But it is not so easy to say what should be done with the results. Purely meteorological results ought, probably, to be reported to the Bureau, and agricultural work should probably be reported to the Department. It might be well to place the meteorological work of the experimental stations and agricultural colleges under the more direct charge of an officer who should be at the head of a subdivision of the Records Division of the Weather Bureau. A temporary arrangement of this sort could be made, and this changed from time to time as appeared to be best, until in the course of time satisfactory relations could be evolved.

NEW HIGH-LEVEL METEOROLOGICAL OBSERVATORIES IN FRANCE.

By A. Lawrence Rotch.

The five mountain observatories on the Puy de Dôme and the Pic du Midi were described in Vol. III. of this Journal. Since this time some notable additions have been made to the chain of high-level stations by the observatories on the Mont Ventoux,

the Aigoual (still unfinished), the Eiffel Tower and Mont Blanc. (See JOURNAL, Vol. VII, No. 9).

THE MONT VENTOUX OBSERVATORY.

The Mont Ventoux, in Provence, is one of the last ramifications of the Alps, rising in a pyramidal mass to the height of 6,250 feet, and giving a superb panorama over the valley of the Rhone. Its flanks, formerly wooded, are now denuded and arid, but the Government has commenced the replanting of them. The employment of this high and isolated summit was proposed by the Meteorological Commission of the Department of Vau-

FIGURE I.—THE OBSERVATORY ON MOUNT VENTOUX.

cluse in 1879, and national and local subscriptions were solicited for the erection of a building which should benefit meteorology (including weather and flood predictions), sericulture, or the raising of silk-worms, which is extensively practiced in this region, and forestry.

It was first necessary to construct a road, twelve miles long, to unite the summit of the mountain with the thoroughfare below, then in 1882 the corner-stone of the Observatory was laid, which in 1885 was opened for meteorological work. The plan of the Observatory is a compromise between those of the Pic du Midi and Puy de Dôme (see Fig. 1). The main building, 100x35 feet, is sunk in the north slope of the summit, having

its principal façade to the south, and a corridor separating in from the mountain. The ground floor (rez-de-chaussée, Fig. 2), is at present unoccupied, but on the first floor, Fig. 3, is the dwelling and the office of the meteorological observer. All the rooms are vaulted, the roof, which rests on the arches of the

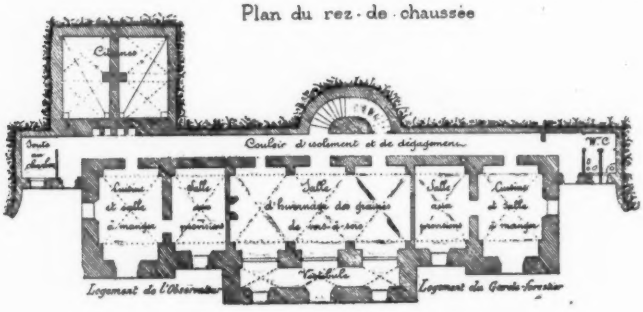


FIGURE 2.

first story, being laid in cement and covered with flagging (see the cross-section in Fig. 4). A special stairway connects the two corridors, and two vaulted cisterns receive the water from the slope (Fig. 2). On the summit of the mountain is a semi-circular platform, on which are placed such meteorological

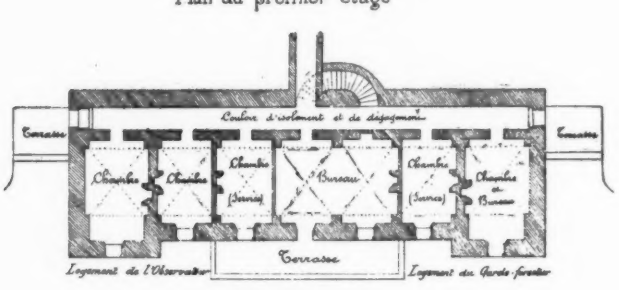


FIGURE 3.

instruments as thermometers, anemometers and rain-gauges (seen to the left in Fig. 1). In ordinary weather this platform is reached by steps outside, but in stormy weather the observer has access to it by a covered stairway (seen in Fig. 3) opening

on the platform. In winter trouble is experienced in maintaining self-recording thermometers or anemometers in operation on account of the "frost-work," together with the violent gales. In winter frost sometimes covers the building and instruments to the thickness of a foot, and iron rods $1\frac{1}{4}$ inches in diameter have been bent double when subjected to the wind under these conditions. No telegraph line could be kept intact until a subterranean cable was laid on the upper part of the mountain. The lightning conductors are on Melsen's system, the collecting points being in clusters grounded in iron pipes, which communicate by cables with a spring on the mountain side. Since

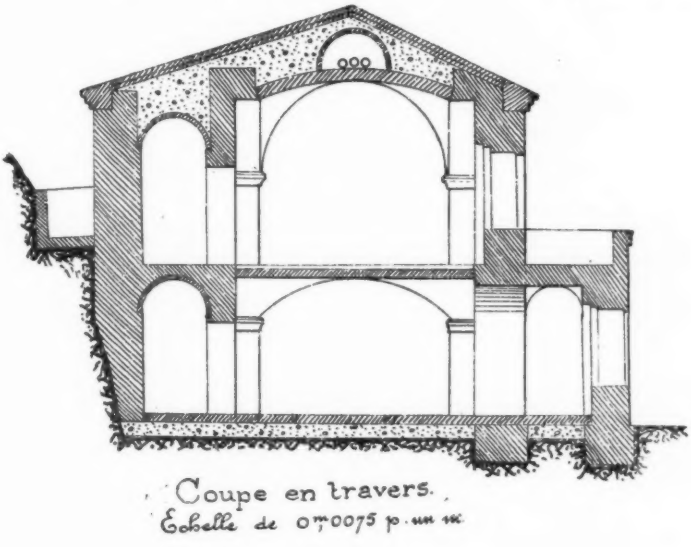


FIGURE 4.

their installation the summit of the Ventoux, formerly the focus of lightning strokes, has been quite protected.

The Observatory is used jointly by the Department of Forests, which is engaged in replanting the mountain and in the raising of silk-worms, and by the Central Meteorological Office, as one of its first-order stations. Six observations are made daily, and two of them are telegraphed to Paris for insertion in the synoptic *Bulletin*. The total cost of this Observatory to

1889 had been about $40,000, nearly half of which was spent in making the road. Up to the present time, it must be admitted that the results of the meteorological observations have been incommensurate with their cost, but under the new administration of the Central Meteorological Office with its telegraphic connection, it seems probable that the Mont Ventoux Observatory will asssume an important position among the French observatories.

THE AIGOUAL OBSERVATORY.

This mountain of the Cevennes, rising to the height of 5,150 feet, offered the following inducements for the establishment of a forest and meteorological station upon its summit:

1. It is the centre of a vast region which is being replanted.

2. It is the point of meeting of the great atmospheric disturbances coming from the ocean to the Mediterranean.

3. It presents a mountain mass completely isolated, with a summit accessible to vehicles. It appeared the more natural to join to an experimental forest station a meteorological observatory, since the ground in process of replanting, as well as the forests already existing upon the flanks of the Aigoual, offer a great variety of soils, in different altitudes and climates.

The project was discussed as long ago as 1869, and in 1884 a government commission, appointed to consider the question, reported as follows: The creation of the Aigoual Observatory will procure to the Administration of Forests the advantages of a refuge, with dwellings and storehouses; it will insure to the Service the possession of an important scientific establishment; it will permit, in the midst of a vast region which is being replanted, the resuming of observations commenced when the soil was mostly barren, which, if continued without interruption until the period when the forests cover the whole mountain, will furnish the data for the solution of the problems relating to the influence of mountain forests upon atmospheric phenomena.

This commission, among whom was M. Vaussenat, the director of the Pic du Midi Observatory, drew up the specifications from which the observatory was built. In an exposed mountain observatory, the principal evils to guard against are lightning, wind and dampness. The first has been here avoided by including no metal-work in the construction and providing a Melsen conductor. Protection from wind is attained by placing the building (100x45 feet in area) below the summit and incased in the rock, so that the roof does not project above the

highest point of the Aigoual, which forms a terrace for geodetic and meteorological instruments. The principal façade is

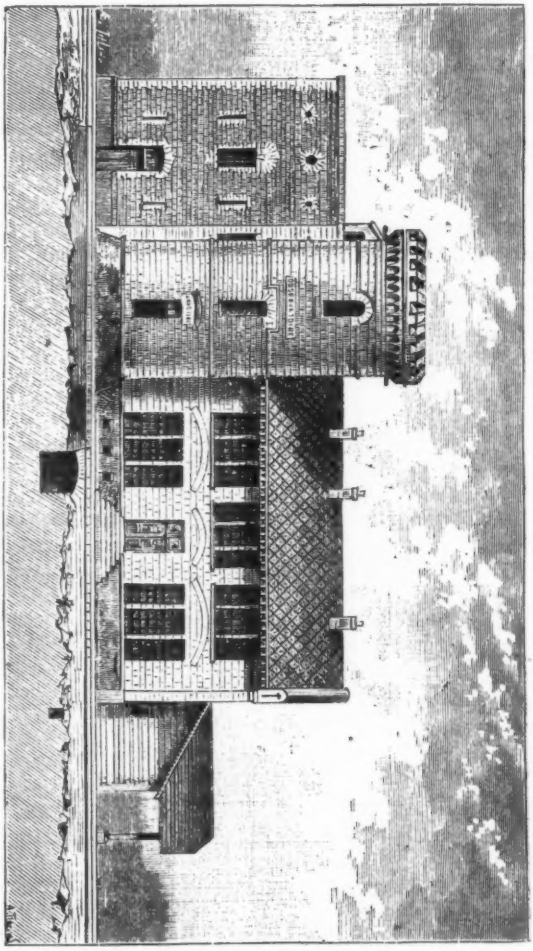


Fig. 1 — Observatoire de l'Aigoual (Gard), à 1567 mètres d'altitude — Élévation de la façade Sud.

turned towards the south, the north side being in the mountain. See Fig. 1. The southwest corner is flanked by a large round

tower (46 feet high) which in the lower story has a visitors' room, on the second floor rooms for scientists, and on the

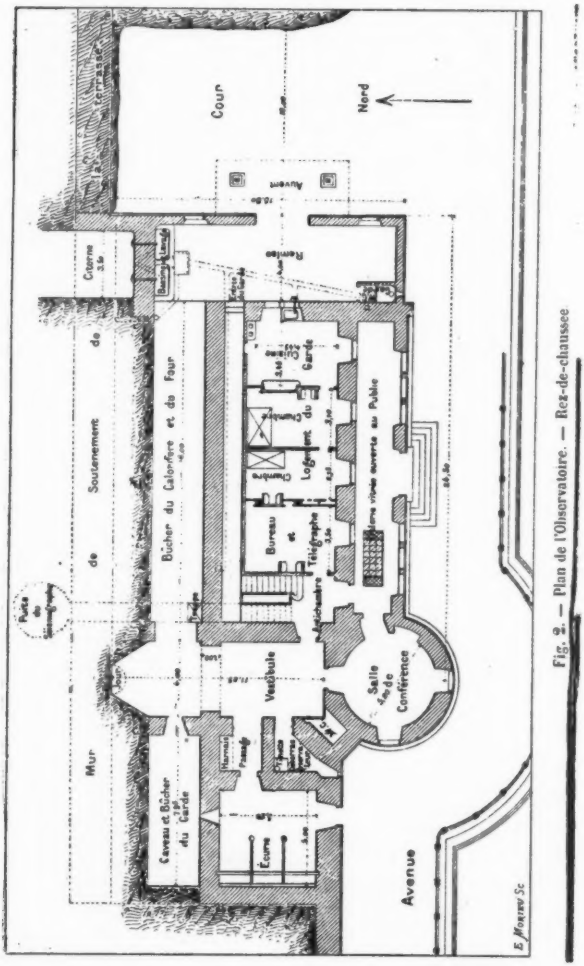


Fig. 2. — Plan de l'Observatoire. — Rez-de-chaussée

summit a platform which dominates that on the mountain itself. [The wing to the left of the tower will not be built at present.]

The main building has a corridor extending all around the various rooms, so that there is really a house within a house (see plan of ground floor in Fig. 2). On the south façade this corridor has on each story large windows, which allow light to penetrate everywhere, while on the north side it occupies the space which separates the dwelling from the mountain. A furnace in the cellar causes the heat to circulate around the walls and insures their dryness, so that any interior humidity, which might arise from condensation, is avoided. On the other hand, the outside walls are built of cut stone, so that they offer to the weathering agents the most resisting materials and the closest joints, and, moreover, as the walls do not adjoin those of the living rooms, they cannot communicate any dampness. In order to secure the necessary stability and rigidity the whole building, including the exterior corridors, is vaulted in cement. Upon this rest the thick slabs of slate forming the roof, which thus fulfills the conditions of solidity, impermeability to water, and non-disintegration by heat and frost. The slates, furthermore, do not contaminate the rain-water falling upon it, which is collected in a cistern as shown in the plan.

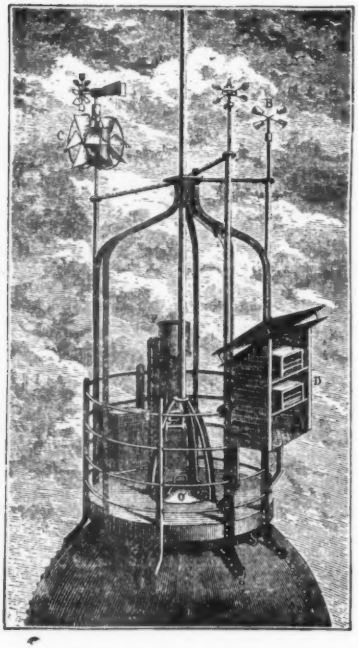
These are the principal features of this Observatory, now nearly finished, and which, with the road uniting it with the village of Camprieu, has cost as much as the Mont Ventoux Observatory, viz.: $40,000. In describing these observatories the details of their construction have been given, because the expense and care which has been devoted to the erection of these well-situated and substantial stations augurs well for the results to be obtained from future work at them.

The Eiffel-Tower Observatory.

The extraordinary advantages for meteorological observations offered by the Eiffel Tower at Paris were early recognized, and upon the summit of the Tower, 980 feet above the ground, was established a meteorological observatory, completely equipped with the self-recording instruments of Richard frères. With the exception of the barometers, which are in a room on the third story of the Tower, 70 feet below the top, the instruments are shown in the accompanying cut, which is reproduced from the French journal *La Nature*. In this view, D is the shelter for the thermometer and hygrometer; P is the rain-gauge; C is an anemometer for the direction and velocity of the wind; A is another anemometer for its horizontal velocity, and B is one for

the vertical air-currents. Access is had to the Observatory through the man-hole O, while a telephone at T permits communication with the ground station.

During the Universal Exposition of 1889 the thermometers and anemometers recorded their indications electrically in the Palace of Liberal Arts. At the close of the Exposition the Central Meteorological Office assumed the maintenance of the Observatory and removed the registers to the Central Bureau, about a a quarter of a mile distant, where a similar series of instruments recorded the atmospheric conditions prevailing near the ground. Side by side, therefore, are recorded simultaneously the temperature and wind in two strata of air more than 900 feet apart vertically. The atmospheric pressure, humidity and rainfall are also recorded on the Tower but are not transmitted, and occasional eye-readings of the barometer and sling thermometers serve to check the automatic records. Recording thermometers have also been established at intermediate points between the base and the summit of the Tower. A discussion of the results thus obtained has shown quite unexpectedly at what a small height some of the meteorological conditions prevailing near the earth's surface are modified or reversed. Some preliminary conclusions have already been given in this JOURNAL, but a more complete study of the various phenomena has just been published by M. Angot, in the *Memoires du Bureau Central Météorologique* de France pour 1889.



THE METEOROLOGICAL OBSERVATORY ON THE EIFFEL TOWER.

The Mont Blanc Observatory.

The cabin of M. Vallot, at the Rocher des Bosses (altitude about 14,400 feet), already described in the JOURNAL, withstood last winter's storms uninjured, and this summer it has been enlarged by the owner. It now contains four rooms for scientists and two for tourists. Owing to delays caused by bad weather the instrumental equipment has not been completed. There is, however, at the cabin a mercurial barograph, which has given some interesting results in connection with one at Chamounix. A pressure anemometer is about to be installed at the cabin. Some interesting comparisons between Crova actinometers read simultaneously at the Rocher des Bosses and at Chamounix, have been made for determining the diurnal values of atmospheric absorption. It is the intention of M. Vallot to publish these observations next winter. Some general results have already appeared in the *Revue Scientifique.*

Not content with the situation of this station M. Janssen, of the French Academy, proposed last year to erect an observatory on the extreme summit of Mont Blanc (altitude 15,780 feet), and he has since succeeded in obtaining the support of influential men, including M. Eiffel, the famous engineer. During the past summer preliminary studies have been made by M. Infeldt, a Swiss engineer. As it is necessary that a firm foundation should be obtained, a horizontal gallery was to be driven through the ice of the highest glacier, just below the summit, until rock was met with, and by means of this gallery the position and formation of the rock buried beneath the ice and snow were to be ascertained. Upon this rock is to be built, upon iron pillars, an observatory 85x20 feet, with a spherical iron roof. It was stated that should the depth of the ice and snow covering the summit exceed thirty feet, the construction of the observatory would be impossible. It is understood that the surveys, now discontinued, have not given encouraging results, and the workmen, who utilized the cabin of M. Vallot as a refuge, suffered much from the cold and the rarefied air. One of the attendant physicians died. It seems, therefore doubtful if this observatory will be built, and indeed whether if its situation upon a snow-capped mountain, would be sufficiently advantageous to warrant great sacrifices of life and money.

METEOROLOGY OF AUSTRALASIA: ACCOUNT OF THE OPERATIONS OF THE CHIEF WEATHER BUREAU.

By Clement L. Wragge, F. R. G. S., F. R. Met. Soc.
(Late of Ben Nevis Observatory). Director of the Chief Weather Bureau, Brisbane.

Impressed with the vast importance of studying atmospheric and climatic phenomena—not only in the cause of science, but practically for the benefit of agriculture, pastoral, shipping, and general interests—the government of Queensland established in January, 1887, a meteorological bureau as a branch of the post and telegraph department of the colony. I was honored by being intrusted with the work of organization and management, and immediately based my plan of action on the lines adopted in the Meteorological Office, London, and Chief Signal Office, Washington, while yet working in strict accordance with the rules of the Royal Meteorological Society. The work is now (June, 1891,) in a very forward state, as the following account will show. It covers not only Queensland, British New Guinea, and the South Pacific Islands; but the whole of Australasia and New Zealand by a system of Intercolonial Exchange, (which was at once set on foot,) and is so rapidly progressing that it bids fair at least to equal any Meteorological and Signal Service at present existing.

Stations supplied with instruments under the new *régime*, number about 500 and are classed as follows:
1st Order, 2nd Order, 3rd Order, 3rd Order A, 3rd Order B.

Stations of the 1st Order are equipped with the following instruments:—Standard barometer, barograph, Stevenson's double-louvred thermometer screens, hygrometers, maximum and minimum self-registering thermometers, thermograph, solar and terrestrial radiation thermometers, earth thermometers, wind-compass and rain-gauge. The hours of observation at stations of this order are 3 A. M., 9 A. M., 3 P. M., and 9 P. M. (local time), and also in some instances at the time, depending on longitude, corresponding to mean noon at Greenwich, when synchronous observations are taken at the principal stations throughout the world.

The equipment of stations of the second order is generally the same as above, with the usual exception of barograph* and thermograph. The hours at these stations are 9 A. M. and 9

* Barographs (Richard pattern) are supplied to second order stations along the coast to assist in hurricane warnings.

P. M. (local time), also in some instances when it is mean noon at Greenwich.

Third order or climatological stations are supplied with a thermometer screen, hygrometer, maximum and minimum self-registering thermometers, wind-compass, and rain-guage; in A division the hygrometer is excepted; and in B division a rain-guage only is employed. The time of observation at all stations of the third order is 9 A. M. only (local).

The instruments at all stations are the best procurable, verified by Kew reference standards.

In addition to elaborate reports by wire daily from stations of the orders above indicated, officers at every post and telegraph office in the colony are instructed to note the wind, amount of cloud, and general conditions of weather at 9 A. M. daily, local time, and to telegraph in many instances their observations forthwith to Brisbane. Reports from all the principal stations are also telegraphed to the other colonies. The observations from all parts of Queensland are collated, together with reports received daily from all the other colonies (including New Zealand), and published on the notice boards at the General Post and Telegraph Office, Brisbane, on Registers,* entitled: "The Weather of Queensland," and "The Weather of Australasia. An outline weather map of Australasia, showing the prevailing winds, areas of clear and cloudy sky, districts where rain has fallen, and lines of equal atmospheric pressure is also regularly exhibited on the boards.

Other reports, if necessary, appear from time to time, and special synopses on Sundays and holidays.

A special report on the weather of Australasia containing a complete digest of the meteorological conditions of each colony is prepared regularly at the Chief Bureau in Brisbane for the press; together with forecasts for all the Australian colonies, including Tasmania and New Zealand. These forecasts, inaugurated before the close of 1887, and since maintained to the present time, are a prominent feature in the new Meteorological Service, and are issued about 5 P. M., thus enabling correspondents of the press to wire them to all parts of Australasia *in*

* These Registers embody records of atmospheric pressure, temperature of air and evaporation in the shade, extreme temperatures within 24 hours, amount of moisture, direction and velocity of wind, extent of cloud, rainfall in inches and tons per acre, and extensive notes and remarks on general meteorological phenomena; so that every facility is offered for studying and comparing the vitally important climatic conditions *of each colony*. Such complete records and opportunities for investigating climatological details covering all the colonies are unique.

time for publication in the morning papers. It is estimated that they are verified to an extent between 80 and 85 per cent. Special ocean forecasts in shipping interests are also issued as occasion requires. These, so far as the southern ocean is concerned, frequently cover four days and are very successful. Thus, at Brisbane, a chief Weather Bureau for all Australasia has actually become established.

Local reports are also issued at Brisbane and other stations. Records from the Brisbane Observatory are published on the boards, several times each day; and the "curves" for pressure, temperature, and moisture, traced by the self-recording instruments, are exhibited side by side with weekly and monthly synopses. These synopses are published regularly in the *Government Gazette* and other papers.

"The Meteorological Record," embracing the results from all important observing stations, is published periodically (monthly if possible), and a General Report annually.

SPECIAL WEATHER CHART OF AUSTRALASIA AT NINE A. M.

A large Weather Chart is also issued for subscribers daily, except Sundays and holidays. This Chart contains graphic delineations of atmospheric conditions derived by wire from seventy-two selected observatories distributed over Western Australia, Northern Territory, Central Australia, South Australia, North Queensland, New South Wales, Victoria, Tasmania and New Zealand, besides collated information from about three hundred smaller stations, and well-fitted meteorological observatories in connection with the Queensland service in New Guinea, New Caledonia, Norfolk Island, the New Hebrides, and Fiji, and data from observing-ships navigating the surrounding oceans. Moreover, additions to the number of stations reporting by wire to the Bureau above are made from time to time as the telegraph lines extend and as new observatories are founded in the vast regions of the Interior.

To meteorologists, geographers, and men of science generally, this new chart has, of course, a special value; while to those interested in the agricultural, pastoral, and shipping pursuits of Australasia, the files have a practical bearing hitherto unequalled.

It is hoped that Fellows of learned societies and British scientists generally will appreciate the efforts of Queensland to place before the world these complete daily meteorological statistics of Australasia—a task never before attempted.

The annual subscription to the Chart is £2 2s. (payable in advance) post free to any part of the Empire.

Specimens may be seen at the office of the Agent-General for Queensland, 1 Westminster Chambers, Victoria street, London; the Meteorological Office, London; Royal Meteorological Society, Great George street, Westminster; Scottish Meteorological Society, Edinburgh; the Smithsonian Institution, and Chief Signal Office, Washington; also at the Parliamentary Library of each Colony; and at the principal Observatories throughout the world; and a specimen copy may be obtained on appplication to myself.

CORRESPONDENCE.

OBSERVATIONS AT A DISTANCE.

To the Editors:—I have just been reading in the "American Meteorological Journal," Vol. 8, page 170, an account by Mr. T. Proctor Hall, of a method of observing from a distance the indications of meteorological instruments by an application of electricity. It may interest you to point out that, as regards the barometer, a method essentially similar was proposed in the year 1882, and may be found described in the English periodical, "*Nature*," Vol. 25, page 559. I have also given a brief description of the same in a paper on the "Barometer," contained in the *Quarterly Journal of the Royal Meteorological Society*, Vol 12, pages 145 and 171. I do not know that the plan was ever tried. William Ellis.

Royal Observatory, Greenwich, England, August 21, 1891.

CURRENT NOTES.

The Authenticity of the Lake Gervais Tornado Photograph.—An absurd error occurred in the heading of Mr. Colton's letter on the Gervais Tornado Photograph, in the October Journal, the word photograph having been omitted.—Editors.

A Lofty Meteorological Station in Peru.—Professor W. K. Pickering writes under date of April 1, 1891: "There is a young Englishman who is to be located at the mines of Cayall-

oma for three years, who is much interested in meteorology. He is intelligent and I have given him a set of instruments. . . . Cayalloma is, perhaps, 70 miles north of here (Arequipa), and perhaps 15,500 feet high. I shall visit it later and determine its altitude, and try to obtain hourly barometric observations for a large part of several days." He also writes June 29, 1891: "Observations of temperature are being made at Cayalloma, and they hope soon to get other observations."

MOUNTAIN AND SEA AIR.—Highly nervous persons, the victims of hypochondria, those suffering from excssive brain work—above all, those in whom these conditions are found in conjunction—should not, as a general rule, be advised to try the sea side. A quiet inland locality, or some mountainous spot of moderate elevation, will be found to suit their cases better. The monotonous aspect of the sea and the ceaseless beat of its waves are mentally depressing, while the highly-strung neurotic patient is irritated instead of braced by the stimulating effects of the sea-air. Those who are just recovering from a serious illness, such as pneumonia or typhoid fever, should not be sent prematurely to the seaside, as an accession of febrile symptoms is frequently the untoward result. An inland locality is more suitable during early convalescence; but, later on, nothing conduces more to complete cure than a resort to the seaside. The marvelously restorative effects of sea air in cases of slight general debility, in persons of strumous habit, and in those with family predisposition to phthisis, are well understood, and must not be regarded as being in any degree impugned by the opinions expressed in the present article.—*British Medical Journal.*

RAIN ABOUT THE NEW LAKE SALTON.—A correspondent of the Weather Bureau writes from Lazuna, San Diego Co., Cal., as follows:

"I am right over and above and in sight of this big Salton Lake that is at present forming on the desert from the Colorado River. I am watching with much interest whether we shall have any local changes of weather. We certainly have had almost unceasing thunder clouds overhead since June 28, and nearly every day since then it has rained on the mountain range next the desert from the Mexican line north for sixty miles, in some place or other. The thunder heads are in sight now, but not so

heavy as during July, August, and the first half of September. I have lived here at Lazuna and Campo, twenty miles south of here, since 1876, and in that time have not seen nearly so much cloudy weather. In other years we have had occasional thunder storms, and after a few days a clearing off, but this year it is almost constantly cloudy, with only two or three clear days in the three months. I expect to see a big inland lake next year after the Colorado River rises with the winter rains, as the channel is opened and ready for it to run into. Three days ago there was no water running at Indian Wells, half way from Colorado River to Salton Lake. The big body of water is still to be seen at the lake, but it will soon evaporate, as the supply is stopped. But we shall see a bigger lake next year, as the Colorado River when it rises and starts to flow in will have no impediments to overcome.

"Some of our cattlemen went down a week ago to see if the six weeks' grass had grown after the overflow, but the water had not receded enough to let it grow. They say no water is flowing."

STORMS OF SEPTEMBER AND OCTOBER.—The latter part of September and almost the entire month of October have been characterized by many and exceptionally severe storms on the North Atlantic. October, especially, has been an abnormally stormy month. Of the two latest and most severe September storms the first passed near and to the east of Bermuda on September 21st, and then recurved and moved east on the 23d and 24th, whilst the very severe hurricane of September 24th was moving rapidly eastward along the transatlantic routes. As soon as the latter moved north of the British Isles the former moved rapidly to the N NE, uniting with the great permanent cyclone near Iceland and adding greatly to its energy.

Three tropical hurricanes have passed north between Hatteras and Bermuda this month, namely, on the 3d, 12th, and 18th. Of these the first originated, apparently about 500 miles E. by N. from Barbadoes on September 28th, and moved northwestward rather slowly, commencing to recurve on the 1st (lat. 26° N., long. 57° W.), but being deflected to the northwestward and passing close to and south of Bermuda the night of the 3d, finally recurving about lat. 38° N., long. 68° W., the morning of the 5th. At 2:30 P. M. on this date, in lat. 40° 39′ N., long. 66° 10′ W., a reliable barometric pressure of 28.57 is

reported, with winds of full hurricane force. Thence the storm moved over Newfoundland and probably across the Atlantic toward the Faroë Islands.

The hurricane east of Hatteras on the 12th originated as a depression of no great energy that crossed the Florida peninsula on the 10th, rapidly gaining energy as it reached the Gulf Stream. This storm was preceded and accompanied by very squally weather and dangerous winds, but no very low pressures have been reported thus far. It crossed Nova Scotia and disappeared to the northward on the 14th.

The hurricane S SW. from Bermuda on the 18th seems to have originated west of Guadeloupe on the 14th, passing northwestward, and close to St. Thomas that night and beginning to recurve north of Santo Domingo on the 16th. It turned to the northward again, however, passed a degree or two west of Bermuda on the 18th, finally recurved about latitude 39° N., longitude 66° W., on the 19th, and moved E NE. over the Grand Banks. The night of the 19th winds of full hurricane force were experienced by vessels near its track, and a pressure as low as 29.11 was reported.

The only other American coast storms worthy of note were the one over New Jersey, on the 20th, and another over the Bay of Fundy, on the 27th, but neither one, apparently, was very severe.

The heavy weather that prevailed between Newfoundland and the British Channel the last week in September was followed by comparatively moderate weather the first two days of October, but a storm that apparently moved easterly in high latitudes on the 2d and 3d caused increasing westerly gales in mid-ocean, and the force of these gales was very greatly increased by the formation of a secondary on the 4th, a short distance west of Rockall. This secondary remained central about the same place for three days, the 4th, 5th and 6th, and during all of this time there was very severe weather almost all the way from the the North Sea to the Grand Banks.

Immediately following the above, a new storm center approached this region from the W SW., probably the hurricane that passed over Sable Island the night of the 5th, although it is not wholly possible as yet to identify the two. The approach and passage of this storm caused a renewal of the heavy westerly gales along the 50th parallel, and these had only just commenced to moderate on the 9th when a new storm center

approached from the NW., causing a renewal of the former conditions.

With only one day's partial intermission on the 12th, another storm approached from the NW. on a track very similar to the last, and apparently united on the 14th with the storm that had approached from the southward and had crossed Ireland on the 13th, accompanied by very heavy gales and pressures as low as 28.08 (at Malin Head, the evening of the 13th). The storm thus formed by the union of these two moved rapidly northward beyond the region of observation.

During the 16th and 17th the weather improved considerably along the transatlantic route, but for the next three days the westerly gales set in with renewed violence, accompanying a storm that was apparently central about lat. 53° N., long. 14° W. on the 20th, and north of Ireland on the 21st. This in turn was followed by the hurricane central over the Grand Banks on the 20th, and moving rapidly along a track about E NE., already referred to. This was succeeded at an interval of about three days by the hurricane that moved along the Nova Scotia coast the afternoon of the 23d, on a northeasterly track, and late reports from incoming vessels indicate a continuance of the very heavy weather that has so generally prevailed. Late European cables contain accounts of further heavy storms and floods throughout western Europe, and the history of the entire month will doubtless make it one of the most severe on record.—*Publications of the Hydrographic Office.*

BOOK NOTICES.

Physical Traces of Cyclone Belts.*—We have received this little brochure of 10 pages containing three charts, and wish to give it brief mention. The author seeks to establish the fact that there is a rather prominent belt, at the latitude of 50° north, over which low pressure areas pass with a considerable constancy around the earth. He also considers that this may have been the case far back in the history of our globe, and even at a time when the materials forming the earth were in a plastic condition. He then shows that a diminution of air pressure of one inch would cause a pull on the earth's surface of 70

*Physical and Geological Traces of Prominent Cyclone Belts, by Marden Manson, C. E., Transactions Technical Society of the Pacific Coast. Vol. VIII, No. 1.

pounds to the square foot and concludes that such a pull would have a tendency to produce areas of elevation along this prominent cyclone belt. It would seem that the facts rather disprove these views even if we grant that the cause adduced was sufficient to produce the effect.

In North America the average path of low pressure areas is over the great lakes and along a depressed area, and, moreover we are taught that the water of these lakes is a determining cause for this trajectory. In Europe there is, to be sure, a mountain barrier extending a little north of 50° in an east and west direction, but it is believed that this barrier is an effective cause for deflecting most storms far to the north. The conception that our low pressure areas were almost the same millions of years ago that they are now, is certainly unique and startling, but it is doubtful whether any one can be persuaded to that belief. We can but feel that there must be a good deal of mistaken zeal in such discussions as this before us. Hz.

BIBLIOGRAPHY OF METEOROLOGY.—The fourth part of this bibliography, embracing the subject of Storms, has just been issued by the Signal Office. The publication of the bibliography, which, with all its imperfections, is of great value to students of meteorology, was commenced in 1888, when, there being no prospect of an appropriation for printing, General Greely decided to lithograph a limited number of copies of some of the most important sub-divisions of the card catalogue. This catalogue had been started by Professor Abbe, in 1881, and was purchased for the use of the office, being combined with the cards received from those persons who had coöperated in the compilation of the bibliography, among the most prominent of whom were Messrs. Symons, of London, and Hellmann, of Berlin.

In the winter of 1889 the division of Temperature, comprising about 4,300 titles and closing with the year 1887, was lithographed from type-written manuscript. In the summer of 1889, this was followed by the division of Moisture, containing about 5,000 titles and closing also with the year 1887. In the fall and winter of 1889–90, the subdivision of Winds, containing about 2,000 titles, brought down to the year 1889, was milliographed from a type-written manuscript, and now the present volume (Storms), comprising about 4,400 titles, is issued by the same process. This volume is edited, like its predecessors, by Mr. O. L.

Fassig, who succeeded Mr. C. T. Sawyer as the bibliographer and librarian of the Signal Office. It includes a main catalogue of the printed literature of meteorology from the origin of printing to the close of 1881, with a supplement to the close of 1889, and an index of authors with the date of their publications.

The three parts include about 16,000 titles, or more than one-fourth of the entire catalogue of 60,000 titles. It is to be hoped that the three remaining volumes contemplated in the scheme for the bibliography may be printed in due form by the Weather Bureau, and that the four volumes already lithographed may also be printed and thereby rendered more legible and accessible to numerous libraries and individuals who have been unable to obtain copies on account of the present limited edition, amounting only to about two hundred and fifty copies. If this is done, the suggestion of Mr. Symons, which has been approved by the Chief Signal Officer, seems a good one, namely that persons discovering errors in their copies should send corrections to the Weather Bureau, so that the parts already lithographed and distributed may serve as proof-sheets for the printed volumes. A. L. R.

A Study of Synoptic Charts of Air Density.*—The density of the air next the earth's surface is largely independent of the barometric pressure, being chiefly controlled by the air temperature and humidity, and since the density of the air may be considered as one of the important causes determining or originating air motions, the idea of charting it and utilizing it in the synoptic work of meteorology has recently occurred to several meteorologists. Among these is Professor Abbe of our Weather Service, who draws attention to its importance in his "Deductive Methods of Weather Prediction." Dr. Ekholm of the Swedish Weather Bureau at Stockholm is also one of the first in this field of study and is probably the first to utilize for current weather predicting, charts showing lines of equal atmospheric density.

From a study of these charts he derives the following conclusions:—

First. The lines of equal atmospheric density over Europe tend to run parallel with the coast, the highest air being over land in summer and over the ocean in winter.

Second. Within the area of a cyclone there is always a

* Étude des Conditions Météorologiques à l' Aide des Cartes Synoptiques representant la Densité de L'Air, par Nils Ekholm.

tongue of rarefied air south of the cyclone extending along the meridian toward the cyclone center.

Third. A cyclone, either primary or secondary, tends to form wherever the air is rarefied and where the lines of equal density lie close together, especially if a tongue of rarefied air extends alongside of a tongue of dense air; or, in short, where the lines of equal density indicate a very unstable equilibrium in the lower atmosphere.

Fourth. In the northern hemisphere cyclones tend to progress along a line nearly parallel to the lines of equal density, leaving the rarefied air to the right.

To the first and second of these propositions, probably, few would be inclined to object because of the well known distribution of temperature over ocean and continents and within the area of a cyclone and because the temperature is one of the most important elements in determining the density of the air.

In regard to the third conclusion, the examples given to illustrate the formation of primary cyclones are for such a small area that they do not appear at all conclusive. The writer believes from the recent researches in this direction that while differences in density in the lower air, within the field of cyclone origin, may be one of the causes originating or modifying the cyclone, the full explanation of cyclone development will not be complete until differences of pressure, density, and atmospheric motion for various altitudes, and for large areas outside of the cyclone are considered.

The formation of secondaries appears to be more intimately connected with the differences of density in the lower air and some of Dr. Ekholm's illustrations of this are quite striking and interesting. In the formation of thunder-showers and local storms it is also probable that the differences in density in the lower air play a very important part.

In regard to the cyclone's progressive motion, the writer is inclined to agree with Dr. Köppen that the lines of equal pressure drawn in the upper air lie closer to the cause of the progressive motion and will give a much better idea of the direction and velocity of motion than lines of equal atmospheric density. However, the writer recently had the pleasure of seeing Dr. Ekholm use these charts of equal density in his daily forecasting work and he felt convinced that this line of work has great interest and probable practical value in forecasting secondary cyclones and local storms. H. H. C.